

## PATENT ABSTRACTS OF JAPAN

(11)Publication number : 59-017530

(43)Date of publication of application : 28.01.1984

(51)Int.Cl.

G02F 1/133

G09F 9/00

(21)Application number : 57-126701

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(22)Date of filing : 22.07.1982

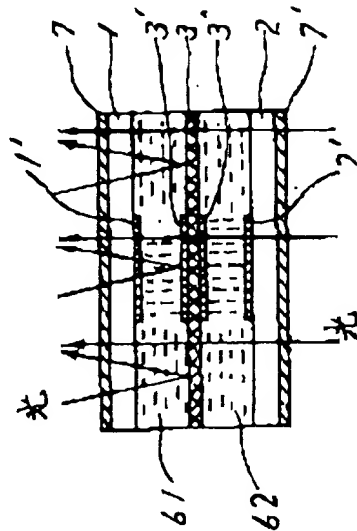
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## (54) LIQUID CRYSTAL DISPLAY ELEMENT

## (57)Abstract:

PURPOSE: To enable displayings which are substantially equal as a whole and are good in both of reflection type and transmission type, by changing the density in both colors of the liquid crystal layer groups on both sides of a translucent plate by changing the density and thickness of the respective liquid crystal layers.

CONSTITUTION: A liquid crystal element is disposed with a milky glass plate 3 of 0.5mm thickness as a translucent plate 3 having both reflectivity transmittance provided with transparent electrodes 3', 3'' at the intermediate of glass substrates 1, 2 having transparent electrodes 1', 2' on the liquid crystal sides. Nematic liquid crystals 61, 62 having positive dielectric anisotropy dissolved with a black dichromatic dye of the same density are held between the respective substrates to about  $10\mu$  so as to be oriented in parallel. Polarization plates 7, 7' are held oppositely in contact with the outside surfaces of the substrates 1, 2 whereby the liquid crystal display element is constituted. A light source for illumination is put behind the element so that the element acts as a reflection type. The element acts as a transmission type in the daytime when external light is strong. When the element is observed in the nighttime where there is no external light or in a room or in a twilight state, the density and contrast of the displayed color do not change and there is no deviation nor out of focus of the display in either case.



## LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the  
examiner's decision of rejection or application  
converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of  
rejection][Date of requesting appeal against examiner's decision  
of rejection]

[Date of extinction of right]

Japanese Laid-open Patent Publication No. 17530/1984

(Tokukaisho 59-17530) (Published on January 28, 1984)

1. TITLE OF INVENTION]

LIQUID CRYSTAL DISPLAY ELEMENT

2. WHAT IS CLAIMED IS:

A liquid crystal display element, arranged so that a liquid crystal layer group is constituted by stacking a plurality of substrates, having transparent electrodes on their surfaces contacting liquid crystal with dichromatic dye dissolved therein, which are disposed opposite to each other so as to sequentially sandwich the liquid crystal, wherein one of the substrates which occupies a gap between the liquid crystal layers is a translucent plate, and another of the substrates is a transparent plate.

3. DETAIL DESCRIPTION OF THE INVENTION

[TECHNICAL FIELD OF THE INVENTION]

The present invention relates to a liquid crystal display element used as both a reflection type and a transmission type in which a plurality of mixed-liquid-crystal layers with dichromatic dye dissolved therein are stacked.

[BACKGROUND OF THE INVENTION AND CONVENTIONAL PROBLEMS]

A liquid crystal display element is categorized into three types: (i) a reflection type which uses external light depending on a condition of illumination, (ii) a transmission type which illuminates

from a rear surface, and (iii) a so-called semi-transmission type, having both characteristics of the reflection type and the transmission type, in which a translucent plate is disposed. However, these conventional liquid crystal display elements have difficulty in realizing preferable display in both daytime and nighttime.

Fig. 1 shows an example of a single-layered-guest-host-type liquid crystal display element having a transmission-type polarization plate. In this example, a mixed liquid crystal (6) with dichromatic dye dissolved therein is held between glass substrates (1) and (2) which are respectively provided with transparent electrodes (1') and (2'), and a polarization plate (7) is provided on an outside surface of the glass substrate (1), thereby realizing a liquid crystal display element (10) which is a transmission type. In this case, there is no member for reflecting light, so that the liquid crystal display element (10) continuously emits light, indicated by an arrow, from its rear surface. Thus, it is possible to obtain preferable display in the nighttime, but when there exists external light, such as sunlight, which is stronger than the illumination on the rear surface, the display is hardly seen. Further, a two-layered liquid crystal display element of Fig. 2 is known as a reflection-type-guest-host liquid crystal display element. The reflection-type display element is arranged so that: liquid crystals (61) and (62) with dichromatic dye dissolved therein are held among three glass substrates (1), (2), and (4), and transparent electrodes

(1'), (2'), (2''), and (4') are provided on the substrates' surfaces which are in contact with the liquid crystal, and a reflection plate (8) is provided. The display element uses external light, so that the displayed image is hardly seen in the nighttime. When a translucent plate is disposed instead of the reflection plate (8) so as to illuminate as shown by an arrow of dotted line, this element functions as a reflection type in the daytime and functions as a transmission type in the nighttime, the displayed image can be seen all time. However, in the reflection type, light goes and returns as shown by a continuous line, but in the transmission type, the light passes through the liquid crystal layer only once. Therefore, in the reflection type, color density is high, and in the transmission type, the color density is low, so that the display quality is different between the nighttime and the daytime. For example, particularly in the transmission type in the nighttime, the contrast drops. Also in case where the translucent plate is provided on the liquid crystal display element (10) of Fig. 1, the display quality likewise varies in the nighttime.

#### [OBJECT OF THE INVENTION]

The object of present invention is to provide a highly practicable semi-transmission type liquid crystal display element improved so as not to change the display density and so as not to change the contrast regardless of whether it is used as the reflection type or as the transmission type.

#### [SUMMARY OF THE INVENTION]

That is, the present invention is a liquid crystal display element which is arranged so that: a plurality of liquid crystal layers with dichromatic dye dissolved therein are stacked via substrates, and any one of the substrates which intervenes between the liquid crystal layers is a translucent substrate having reflectivity and transmissivity, and transparent electrodes are provided on its surface contacting the liquid crystal as in another substrate, thereby substantially equalizing color density of a reflection type to color density of a transmission type.

The liquid crystal display element does not change the display density and does not change the contrast regardless of whether it is used as the reflection type or as the transmission type. Thus, this display element can be regarded as a semi-transmission type liquid crystal display element which is more practicable and has higher display quality.

Here, the description is given on the assumption that: a substrate between a first liquid crystal layer and a second liquid crystal layer is a translucent plate having the reflectivity and the transmissivity, and an illumination light source is disposed opposite to the translucent plate of one of the liquid crystal layers, for example, the second liquid crystal layer. In case of using the display element without turning on the illumination light source under strong external light, the external light passes through the first liquid crystal layer, and is absorbed by dye contained in the liquid crystal, and is weakened, and is reflected by the translucent plate,

and passes through the first liquid crystal layer again, and is further weakened, and is reflected. Further, in case of turning on the illumination light source without any external light, light weakened by the second liquid crystal layer passes through the second liquid crystal layer after passing through the translucent plate, so that the light is further weakened and is transmitted. Thus, by setting the dye density of the first and second liquid crystal layers and the reflectivity and the transmissivity of the translucent plate to appropriate values, it is possible to substantially equalize the color density and the contrast of the reflection type to the color density and the contrast of the transmission type, thereby improving the practicability and the display quality.

For example, two liquid crystal display elements (10) shown in Fig. 1 are combined with each other via the translucent plate (9) as shown in Fig. 3. In this case, the first liquid crystal layer and the second liquid crystal layer are separated from each other by a distance corresponding to a thickness of two glass substrates and the translucent plate. Thus, when viewed on the basis of the reflection type or the transmission type, deviation occurs in the displayed image, and when viewed on the basis of the transmission type, the second liquid crystal layer is separated from the translucent plate, so that the displayed image seems obscure.

In order to solve such problems, in the present invention, the translucent plate functions also as a substrate for holding both the first and second liquid crystal layers, so that a distance between the

first and second liquid crystal layers corresponds to a thickness of merely the translucent plate. As a result, merely by making the translucent plate thinner, it is possible to substantially prevent the deviation of the displayed image and it is possible to prevent the displayed image from being obscure, thereby further improving the display quality.

#### [EXAMPLES OF THE INVENTION]

The following description will explain examples of the present invention.

In an example of an element shown in Fig. 4, a liquid crystal element is arranged so that: a milky glass plate (3) of 0.5mm thickness is disposed as a translucent plate (3), having both the reflectivity and the transmissivity, whose one surface has a transparent electrode (3') and other surface has a transparent electrode (3''), between glass substrates (1) and (2) having a transparent electrode (1') or (2''), and nematic liquid crystals (61) and (62), having positive dielectric anisotropy, which contain black dichromatic dye of the same density dissolved therein, are held between the respective substrates to about 10 $\mu$  so as to be oriented in parallel. Further, polarization plates (7) and (7') are held oppositely in contact with the outside surfaces of the substrates (1) and (2), thereby constituting the liquid crystal display element. An illumination light source is disposed on a rear surface of the element so that the element acts as a reflection type in the daytime when external light is strong and acts as a transmission type in the

nighttime when there is no external light. When the element is observed in the nighttime where there is no external light or in a room or in a twilight state, it is possible to substantially prevent the deviation of the displayed image and it is possible to prevent the displayed image from being obscure, thereby further improving the display quality.

Fig. 5 shows another example of the element. A glass substrate (1) having a transparent electrode (1'), a glass substrate (2) whose one surface has a transparent electrode (2') and other surface has a transparent electrode (2''), a translucent plate (3), made of milky glass of 0.5mm thickness, whose one surface has a transparent electrode (3') and other surface has a transparent electrode (3''), a glass substrate (4) whose one surface has a transparent electrode (4') and other surface has a transparent electrode (4''), and a glass substrate (5) having a transparent electrode (5') are disposed in this order. Nematic liquid crystals (61), (62), (63), and (64), having dielectric anisotropy, which contain black dichromatic dye of the same density dissolved therein, are held among the respective substrates opposite to each other so that the nematic liquid crystals are in contact with the transparent electrodes. At this time, all the liquid crystals (61), (62), (63), and (64) are aligned in parallel to each other so that an alignment direction of the liquid crystals (61) and (62) is orthogonal to an alignment direction of the liquid crystals (63) and (64).

When an illumination light source is disposed on a rear

surface of the semi-transmission type liquid crystal display element arranged in this manner and is operated, it is possible to realize a practicable display element which hardly changes the display density and the contrast regardless of whether it is used as the reflection type or as the transmission type and substantially prevents the deviation of the displayed image and it is possible to prevent the displayed image from being obscure, thereby further improving the display quality.

In both examples, both portions sandwiching the translucent plate are constituted as single-layered portions or are constituted as two-layered portions, but it may be so arranged that: the one portion is constituted as a single-layered portion, and the other portion is constituted as a two-layered portion. As the translucent plate, milky glass (opal glass) is used, but it is possible to use a transparent plastic plate or a transparent film such as a milky acrylic plate, and it is also possible to use a plate obtained by slightly applying light diffusing material such as white pigment on at least one side of the transparent substrate or the transparent film. Further, the translucent plate may be entirely or partially colored. The translucent plate obtained in this manner has a light diffusing property and causes the displayed image to be slightly obscure. However, it may be so arranged that: for example, a transparent substrate or a transparent film is used, and a reflection surface is formed in a mesh manner or in a stripe manner, thereby obtaining a translucent plate in which reflection portions and transmission

portions are mixed with each other. In this case, it is possible to prevent the displayed image from being obscure.

#### [EFFECTS OF THE INVENTION]

According to the invention, by changing the density and the thickness of each liquid crystal layer, it is possible to equalize the color densities of the liquid crystal layer groups disposed on both sides of the translucent plate as a whole, so that the display element is used as the reflection type and as the transmission type, thereby realizing preferable display.

#### 4. BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 and Fig. 2 are cross sectional views of conventional liquid crystal display elements.

Fig. 3 is a cross sectional view of a liquid crystal display element shown as a comparative example.

Fig. 4 and Fig. 5 are cross sectional views of liquid crystal display elements shown as examples of the present invention.

(1), (2), (4), and (5) ... glass substrates

(1'), (2'), (2''), (3'), (3''), (4'), (4''), and (5') ... transparent electrodes

(3) and (9) ... translucent plates

(7) and (7') ... polarization plates

(8) ... reflection plate

(6), (61), (62), (63), and (64) ... liquid crystals

(10) and (11) ... liquid crystal display elements

⑩ 日本国特許庁 (JP)

⑪ 特許出願公開

⑫ 公開特許公報 (A)

昭59—17530

⑬ Int. Cl.<sup>3</sup>

G 02 F 1/133

G 09 F 9/00

識別記号

庁内整理番号

7348—2H

6865—5C

⑭ 公開 昭和59年(1984)1月28日

発明の数 1

審査請求 未請求

(全 4 頁)

⑮ 液晶表示素子

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## 明 細 書

## 1. 発明の名称

液晶表示素子

## 2. 特許請求の範囲

二色性染料を溶解している液晶を、液晶に接触する面に透明電極を備えて対向する複数の基板の対向間隔に順次挟持させて積層している液晶層群の、液晶層と液晶層の間を占めるいずれか基板の一が、半透過板であり、その他は透過板であることを特徴とする液晶表示素子。

## 3. 発明の詳細な説明

(発明の技術分野)

この発明は二色性染料を溶解している液晶層の複数の液晶層を積層した反射透過両方兼用の液晶表示素子に関する。

(発明の技術的背景とその問題点)

液晶表示素子は本来受光形の素子であつて、照明条件により外光を利用する反射形、背面から照明する透過形、更に反射性と透過性の両性を受けとるいわゆる半透過型を配設した半透過形の

三種に分けられる。しかしいずれの形式の液晶表示素子においても、従来のものは昼夜とも良好な表示をすることが困難である。

いそ透過形の偏光板付き半層グストホスト方式の液晶表示素子例を図1図に示す。この例は透明基板(1)、(2)を備えるガラス基板(1)、(2)間に二色性染料を溶解している液晶層(4)を保持させ、一方のガラス基板(1)の外側面に偏光板(7)を設けて液晶表示素子10とした透過形である。この場合、光を反射するものがないため、背景背面から以下矢印で示す光を照射して使用する。従つて、夜間は良好な表示が得られるが、背景の照明より強い直射日光などの外光が存在する場合、表示を見えなくする欠点がある。また反射形のグストホスト方式の液晶表示素子として図2図の二層構造のものが知られている。二枚のガラス基板(1)、(2)、(4)間に二色性染料を含有する液晶(61)、(62)を保持させ、前記基板の液晶と接する面には透明基板(1')、(2')、(2') (4')を設けて液晶表示素子11とし、これに反射板(8)を設けた反射形の表示素子である。この素子

(1)

—165—

(2)

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は外光を利用するため夜間に表示を見えなくする。反射面(8)の代りに半透過板を置き背面から点滅矢印で示すように照明した場合、昼間は反射形、夜間は透過形として機能して、常時表示が見えるようになる。しかし反射形では真鍮で示すように光が透過するのに対し、透過形では一面しか液晶層を透過しない。したがって反射形では色温度が高く透過形では低くなり、特に夜間の透過形ではコントラストが低下するなど、夜間の表示品位が変化する欠点がある。第1図の液晶表示素子(10)に半透過板を付設した場合にも上記同様、夜間の表示品位が変化する。

## 〔発明の目的〕

この発明は、このような反射形又は透過形の何れの状態で使用しても表示の品位を低下させず、又コントラスト低下をもなくするように改良された実用性の高い半透過形液晶表示素子を提供することにある。

## 〔発明の要旨〕

既述の発明は、二色性染料を溶解している液

(3)

晶層を基板を介して液晶層を挟み且つ液晶層と液晶層の間にある何れか一の基板が光反射性と光透過性の両性を備えた半透過板であり、<sup>(1)(2)(3)(4)(5)(6)(7)(8)(9)(10)(11)(12)(13)(14)(15)(16)(17)(18)(19)(20)(21)(22)(23)(24)(25)(26)(27)(28)(29)(30)(31)(32)(33)(34)(35)(36)(37)(38)(39)(40)(41)(42)(43)(44)(45)(46)(47)(48)(49)(50)(51)(52)(53)(54)(55)(56)(57)(58)(59)(60)(61)(62)(63)(64)(65)(66)(67)(68)(69)(70)(71)(72)(73)(74)(75)(76)(77)(78)(79)(80)(81)(82)(83)(84)(85)(86)(87)(88)(89)(90)(91)(92)(93)(94)(95)(96)(97)(98)(99)(100)</sup>何れかの基板とは他の基板と同様に液晶層に接触する面に透明電極を設け、反射形での色温度と透過形での色温度を實質的に等しくしたことを特徴とする液晶表示素子にある。

反射又は透過の何れの状態で使用してもこの液晶表示素子は表示品位を低下させず、又コントラストを低下させない。それ故実用性を、又表示品位を共に高めた半透過形液晶表示素子といえる。

いま第一の液晶層と第二の液晶層の間にある基板を反射性と透過性の両性の半透過板とし、そして一方の液晶層例えば第二の液晶層の半透過板とは反射面に照明光源を置くとする。強い外光のもとで照明光源を点灯せずに使用する場合に、外光は第一の液晶層を透過して液晶中の染料による吸収を受け、<sup>(1)(2)(3)(4)(5)(6)(7)(8)(9)(10)(11)(12)(13)(14)(15)(16)(17)(18)(19)(20)(21)(22)(23)(24)(25)(26)(27)(28)(29)(30)(31)(32)(33)(34)(35)(36)(37)(38)(39)(40)(41)(42)(43)(44)(45)(46)(47)(48)(49)(50)(51)(52)(53)(54)(55)(56)(57)(58)(59)(60)(61)(62)(63)(64)(65)(66)(67)(68)(69)(70)(71)(72)(73)(74)(75)(76)(77)(78)(79)(80)(81)(82)(83)(84)(85)(86)(87)(88)(89)(90)(91)(92)(93)(94)(95)(96)(97)(98)(99)(100)</sup>何れかの半透過板で反射され再び第一の液晶層を透過し、更に何れかの反射面を

(4)

る。また外光がなく照明光源を点灯した場合には第二の液晶層で封められた外光は、半透過板を透過して第二の液晶層を透過することにより更に封められて透過してくる。従つて第一と第二の液晶層の染料濃度及び半透過板の反射及び透過性能を適正値に設定することにより反射状態で見た時と透過状態で見た時の色の温度やコントラストを實質的に等しくでき、実用性と表示品位を高めることが出来る。

そこで例えば第1図に示した液晶表示素子(10)を二個、第3図に示すように半透過板(1)を介して重ね合わせるとする。この場合には第一の液晶層と第二の液晶層が、ガラス基板二枚分と半透過板の厚みだけ離れてしまい、反射又は透過で見た場合表示にずれを生じ更に透過の場合には第二の液晶層と半透過板が離れてあるため、表示がぼけてしまう。

このような事象に対処する発明にあつては半透過板自体が第一と第二の液晶層両層を保持する基板をかねているため、第一と第二の液晶層の距離

(5)

は半透過板の厚みのみとなり、半透過板を薄くしさえすれば實質的に表示のずれ及びぼけを解消でき、表示品位を更に向上させる。

## 〔発明の実施例〕

以下にこの発明の実施例について述べる。

第4図に示す素子例は、何れも液晶側に透明電極(1')又は(2')を備えたガラス基板(1)と(2)との間に、透明電極(3')を一方の面に、透明電極(3'')を他方の面に備えた反射性、透過性両性能の半透過板(3)として0.5mm厚の乳白ガラス板(9)を配置し、両面側の黒色の二色性染料を溶解した防曇剤方性正のネマチック液晶(61)、(62)を平行配向するように約10μmの厚さ各層間に供給させてある。又ガラス基板(1)、(2)の外周には偏光板(7)、(7')を別装させ液晶表示素子を構成してある。

この半透過形液晶表示素子の背面に照明光源を置き、反射形として外光の強い昼間に、透過形として外光のない夜間に、或いは反射又は透過の何れ形として外光の比較的弱い室内や陽子の状態でこの素子を観察した結果、いずれの状態においても

(6)

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表示色の濃さとコントラストがほとんど変化せず更に表示のずれやぼけもなく表示品位を良好にする。

図5図に他の実施例を示す透明基板(1')を備えるガラス基板(1)、透明電極(2')を一方の面に、透明電極(2')を他方の面に備えるガラス基板(2)、透明電極(3')を一方の面に、透明電極(3')を他方の面に備える0.5mm厚の乳白ガラスからなる半透過板(3)、透明電極(4')を一方の面に、透明電極(4')を他方の面に備えるガラス基板(4)、そして透明電極(5')を備えるガラス基板(5)が順に配設されている。透明電極に接するように各基板の対向間隔に同一配向の黒色染料を溶解したポリイオン性正のネマチック液晶(61)、(62)、(63)、(64)を保持させる。この液晶(61)、(62)、(63)、(64)は全て、平行配向でかつ(61)と(62)、(63)と(64)の配向方向が直交するようにしてある。

このように形成されている半透過形の液晶表示素子の背面に照明光源を配置したところ、反射形として或いは透過形として何れによつて使

(7)

このようにこの発明によれば半透過板の両面に、ある液晶層の両色配向を、それぞれの液晶層の濃度及び厚さを変えることにより、全体として実質的に等しくとることが出来、反射形、透過形の両方に用いて表示を良好にさせる。

#### 4. 図面の簡単な説明

第1図及び第2図は従来の液晶表示素子の断面図、

第3図は比較例液晶表示素子の断面図、

第4図及び第5図は何れもこの発明の実施例液晶表示素子の断面図である。

各図で

(1)、(2)、(4)、(5)…ガラス基板、

(1')、(2')、(2'')、(3')、(3'')、(4')、(4'')、(5')…透明電極、

(3)、(9)…半透過板、

(7)、(7')…偏光板、

(8)…反射板、

(61)、(62)、(63)、(64)…液晶、

01、02…液晶表示素子。

代理人 齊藤士 井 上 一 男

(9)

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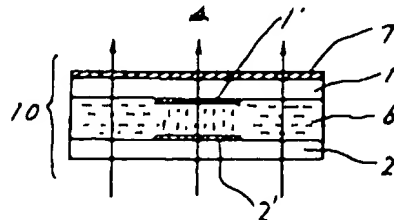
用しても、表示の濃さやコントラストの低下が少なく、更に表示のずれやぼけをほとんどなくし、経度にかかわらず表示品位を良好にして実用性ある表示素子となっている。

実施例では、半透過板を何れに何れも半層又は二層構造をとっているが、一方で半層で他方で二層構造をとつてもよい。又半透過板として乳白ガラス(オパールガラス)を使用しているが、この乳白アクリル板などの半透過性のプラスチック板やフィルム、更に透明な基板やフィルムの少なくとも一方の面に白色顔料など、光拡散性材料を細く分散したものを用いてもよい。又この半透過板は全体を、或いはその一部を選択して色付けられてもよい。これらの半透過板は光拡散性をして多少の表示のぼけを生じるが、例えば透明基板やフィルムを用い、ノックアウトあるいはストライプ状に反射面を形成し、反射部分と透過部分が混在した半透過板を用いてもよく、この場合には表示のぼけが解消できる。

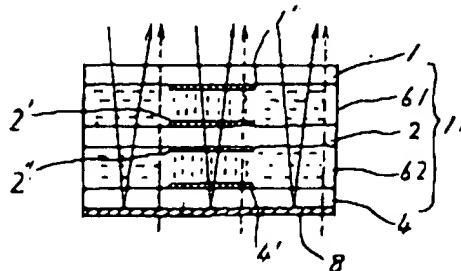
(発明の効果)

(8)

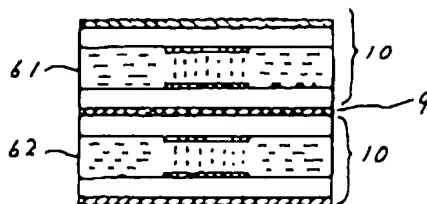
第1図



第2図

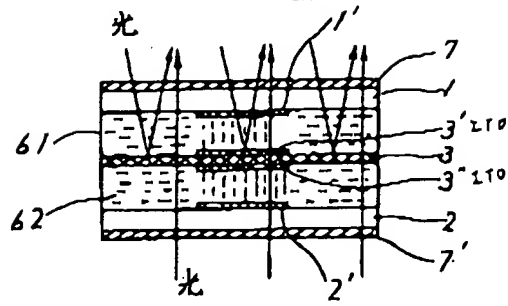


第3図



特開2005-17530 (4)

第 4 図



第 5 図

